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FOREST PRODUCTS LABORATORY SERIES.

SERVICE TESTS OF TIES.

PROGRESS REPORT

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SERVICE TESTS OF TIES: PROGRESS REPORT.

THE NEED FOR SERVICE TESTS.

At the present time all railway maintenance engineers admit the advisability of protecting wooden crossties from decay and mechanical abrasion. The increasing number of ties which are given treatment and the many forms of mechanical devices to protect them against wear indicate this attitude. Nevertheless, opinions on the efficiency of the various treatments and devices differ widely because there is very little reliable information to show what method of preserving ties from decay is best or what kind of rail fastening yields most satisfactory results. To secure this knowledge some railroads have made efforts to keep records of the life of their ties by the use of dating nails or other means. Experience has shown, however, that it is practically impossible to secure satisfactory records by attempting to include all the ties placed. Much more accurate and valuable information can be secured, at lower cost, by obtaining complete records on a comparatively few representative ties than by incomplete or doubtful records covering all ties in service. For this reason special tests are now considered more valuable, and the former practice of driving dating nails into all treated ties is falling into disuse.

The demand for definite information on the durability of ties under conditions of service can not be met by laboratory experiments, because the conditions of practice can not be duplicated in the laboratory, nor can they be even remotely approached. Therefore the Forest Service undertook, in cooperation with various railroads and tie-treating plants, to obtain durability records of ties in actual service by means of carefully planned tests. The first test was started in 1902; at the present time there are in various parts of the country eight test tracks which have been established through this cooperation.

PURPOSE OF THE PUBLICATION.

This report is a record of the test tracks which have been laid and makes available the results which have thus far been secured. Owing to the complexity of the problem, and to the fact that in

most cases deterioration takes place slowly, many years must elapse before final conclusions can be drawn.[1]

GENERAL PROCEDURE IN THE TESTS.

In these investigations it is the general practice for the railroad companies to bear the entire expense of furnishing and treating the ties and placing them in the roadbed. The Forest Service plans the investigation, supervises the treating and the placing of the ties, makes frequent inspections, and compiles the data. With the exception of the ties placed in the track of the Chicago, Milwaukee & St. Paul Railway Co., all of the treated ties were treated in commercial plants. The test ties in the Chicago, Milwaukee & St. Paul track were treated in the experimental cylinder of the Forest Products Laboratory and in their case more complete records of their treatment are available than in any other.

In the inspections the following scheme is used for describing and classifying the ties:

Decayed.—Ties so decayed as to warrant their early removal from the track.

Partially decayed.—Ties partially affected with decay but still serviceable.

Split.—Ties noticeably split or checked but still serviceable.

Worn.—Ties noticeably damaged by rail or plate cutting but still serviceable.

Spike cut.—Ties in which the spikes are noticeably loose or have damaged the wood.

Good.—Ties not noticeably affected with decay and not badly split, checked, worn, or spiked.

In certain instances it has been agreed that no ties removed from a test track for any cause whatever will be destroyed until a representative of the Forest Service has inspected them. There was no such agreement, however, with the Gulf, Colorado & Santa Fe Railway Co., and the records of the Forest Service applying to this road are now so incomplete that no further examination of this track will be made by the Forest Service.

Throughout this publication patented and proprietary preservatives and processes are designated by the names by which they are generally known.

[1] For a record of test tracks laid by various railroads in the United States independent of the Forest Service, see Bulletin 144 (vol. 13) of the American Railway Engineering Association.

RECORDS OF TESTS.

TEST TRACK LAID IN COOPERATION WITH THE GULF, COLORADO & SANTA FE RAILWAY CO.

DESCRIPTION OF TRACK.[1]

The 5,477 ties which were placed in the test track laid in cooperation with the Gulf, Colorado & Santa Fe Railway Co. were laid in February, 1902, in a level tangent between Pelican and Cleveland, Tex. No tie-plates were used and the rails were spiked to the ties with ordinary cut spikes. The ballast was composed largely of densely packed sand, banked in the middle; the ends of the ties were exposed. Sixty and sixty-one pound rails were used. The drainage is poor; the traffic, which is mostly westward, averaged about 166,000 tons per month at the time the test ties were placed.

OBJECTS OF THE TEST.

This test was designed to obtain information as to:

(1) The durability of ties made from untreated beach; hemlock; black, red, Spanish, turkey, white, and willow oak; loblolly, longleaf, and shortleaf pine; and tamarack.

(2) The efficiency of the Allardyce, Burnett, Hasselmann, and Wellhouse processes, and of preservative treatments with Beaumont oil, with spirittine, and with zinc chloride in combination with Beaumont oil and with English creosote.

TREATMENT.

The ties treated for this track were obtained from various sources and it was impossible at the time to use great care in selecting them. Many of the ties, therefore, were possibly not of the best of their kind. The descriptions of the treatments of the various lots of ties, given in connection with Tables 1 to 11, which show their condition, are based on the reports made by the persons in charge of the treatments. The number of ties of each species treated by any one plant by a given process was relatively small and various species were treated in the same charge. The absorption records for the charges are therefore of doubtful value as to any one species.

[1] A report of the laying of this track and of the first and second inspections is given in Bulletin 51, "Condition of Treated Timbers Laid in Texas in 1902," by Hermann von Schrenk.

TABLE 1.—*Condition of ties treated by the Allardyce process,*[1] *at Somervilie, Tex., after seven and one-half years' service.*

Kind of wood.	Original number placed.	Ties remaining in track.					Serviceable ties remaining in track.			
		Decayed.	Partially decayed.	Good.	Split.	Total.	Partially decayed.	Good.	Split.	Total.
		No.	*No.*	*No.*	*No.*	*No.*	*Per ct.*[2]	*Per ct.*[2]	*Per ct.*[2]	*Per ct.*[2]
Beech	50	7	7	27	9	50	14	54	18	86
Hemlock	50	19	10	11	10	50	20	22	20	62
Oak, black	60	3	3	36	18	60	5	60	30	95
Oak, red	10	.....	.....	10	.....	10	.....	100	.....	100
Oak, Spanish	10	1	2	7	.....	10	20	70	.....	90
Oak, turkey	10	.....	.....	10	.....	10	.....	100	.....	100
Oak, white	100	2	7	69	20	98	7	69	20	96
Oak, willow	10	1	4	5	.....	10	40	50	.....	90
Pine, loblolly	50	16	6	10	17	49	12	20	34	66
Pine, longleaf[3]	50	.....	.....	31	12	43	.....	62	24	86
Pine, shortleaf[3]	50	.....	.....	28	.....	28	.....	56	.....	56
Tamarack	50	7	5	32	5	49	10	64	10	84
Total	500	56	44	276	91	467	9	55	18	81

[1] These ties were treated at the plant of the Texas Tie & Lumber Preserving Co. Various species were treated in the same charge and the ties were given an average injection of 12 pounds of 2 per cent zinc chloride solution per cubic foot, followed immediately by an average injection of 3 pounds of creosote per cubic foot.

[2] Based on number of ties originally placed.

[3] Because of a change made in the location of some of the longleaf and shortleaf pine ties and of the loss of some of the marking rails, there is some doubt as to the accuracy of the records.

TABLE 2.—*Condition of ties treated with Beaumont oil,*[1] *at Somerville, Tex., after seven and one-half years' service.*

Kind of wood.	Original number placed.	Ties remaining in track.					Serviceable ties remaining in track.			
		Decayed.	Partially decayed.	Good.	Split.	Total.	Partially decayed.	Good.	Split.	Total.
		No.	*No.*	*No.*	*No.*	*No.*	*Per ct.*[2]	*Per ct.*[2]	*Per ct.*[2]	*Per ct.*[2]
Pine, loblolly	42	2	.....	.....	.....	2	.....	.....	.....	.....
Pine, longleaf	100	23	4	3	.....	30	4	3	.....	7
Total	142	25	4	3	.....	32	3	2	.....	5

[1] The treatment consisted of soaking the ties in the oil for 24 hours. The longleaf pine absorbed on an average 5.67 pounds, and the loblolly pine 4.24 pounds, per tie; the latter were not thoroughly seasoned before treatment.

[2] Based on number of ties originally placed.

TABLE 3.—*Condition of ties treated by the Burnett process,[1] at Chicago, Ill., after seven and one-half years' service.*

Kind of wood.	Absorption dry salt.[2]	Original number placed.	Ties remaining in track.					Serviceable ties remaining in track.			
			Decayed.	Partially decayed.	Good.	Split.	Total.	Partially decayed.	Good.	Split.	Total.
	Lb. per cu. ft.		*No.*	*No.*	*No.*	*No.*	*No.*	*Per ct.*[3]	*Per ct.*[3]	*Per ct.*[3]	*Per ct.*[3]
Beech	0.41	99	8	33	39	19	99	33	40	19	92
Hemlock[4]	.62	100	.....	7	35	27	69	7	35	27	69
Oak, red	.....	86	14	15	33	21	83	17	38	24	79
Oak, white	.26	101	.....	4	76	21	101	4	75	20	100
Tamarack	.41	49	1	3	32	13	49	6	65	26	98
Total	.....	435	23	62	215	101	401	14	50	23	87

[1] These ties were treated by the Chicago Tie & Timber Preserving Co. The treatment consisted of impregnation with a 4 per cent solution of zinc chloride.
[2] Based on weights of sample ties of each lot before and after treatment.
[3] Based on number of ties originally placed.
[4] Because of a change made in the location of some of the hemlock ties and of the loss of some of the marking nails there is some doubt as to the accuracy of the records.

TABLE 4.—*Condition of ties treated by the Burnett process,[1] at Somerville, Tex., after seven and one-half years' service.*

Kind of wood.	Original number placed.	Ties remaining in track.					Serviceable ties remaining in track.			
		Decayed.	Partially decayed.	Good.	Split.	Total.	Partially decayed.	Good.	Split.	Total.
	No.	*No.*	*No.*	*No.*	*No.*	*No.*	*Per ct.*[2]	*Per ct.*[2]	*Per ct.*[2]	*Per ct.*[2]
Oak, black	34	2	7	14	6	29	20	41	17	78
Oak, red	20	.....	.....	.....	.....	.....	.....	.....	.....	.....
Oak, Spanish	21	.....	.....	15	1	16	.....	71	5	76
Oak, turkey	20	.....	.....	.....	.....	.....	.....	.....	.....	.....
Oak, white	100	.....	.....	.....	.....	.....	.....	.....	.....	.....
Oak, willow	20	.....	.....	.....	.....	.....	.....	.....	.....	.....
Pine, loblolly	100	22	10	37	30	99	10	37	30	77
Pine, longleaf[3]	100	1	2	57	14	74	2	57	14	73
Pine, shortleaf[3]	100	.....	2	37	.....	39	2	37	.....	39
Total	515	25	21	160	51	257	4	31	10	45

[1] These ties were treated at the plant of the Texas Tie & Lumber Preserving Co. with a 2 per cent solution of zinc chloride. Various species were treated in the same charge; the average absorption for all species was 0.35 pound of dry salt per cubic foot.
[2] Based on number of ties originally placed.
[3] On account of a change made in the location of some of the longleaf and shortleaf pine ties and of the loss of some of the marking nails there is some doubt as to the accuracy of the records.

TABLE 5.—*Condition of ties treated by the Hasselmann process,*[1] *at Somerville, Tex., after seven and one-half years' service.*

Kind of wood.	Original number placed.	Ties remaining in track.					Serviceable ties remaining in track.			
		Decayed.	Partially decayed.	Good.	Split.	Total.	Partially decayed.	Good.	Split.	Total.
		No.	*No.*	*No.*	*No.*	*No.*	*Per ct.*[2]	*Per ct.*[2]	*Per ct.*[2]	*Per ct.*[2]
Beech	98	.....	.....	.....	.....	.....	.....	.....	.....	.....
Hemlock	100	.....	.....	.....	.....	.....	.....	.....	.....	.....
Oak, black	118	.....	.....	.....	.....	.....	.....	.....	.....	.....
Oak, red	19	.....	.....	.....	.....	.....	.....	.....	.....	.....
Oak, Spanish	20	.....	.....	.....	.....	.....	.....	.....	.....	.....
Oak, turkey	19	.....	.....	.....	.....	.....	.....	.....	.....	.....
Oak, white	196	1	7	22	2	32	3	11	1	15
Oak, willow	20	.....	.....	.....	.....	.....	.....	.....	.....	.....
Pine, loblolly	99	.....	.....	.....	.....	.....	.....	.....	.....	.....
Pine, longleaf	100	.....	.....	5	.....	5	.....	5	.....	5
Pine, redheart	100	.....	.....	.....	.....	.....	.....	.....	.....	.....
Pine, shortleaf	98	.....	.....	1	.....	1	.....	1	.....	1
Tamarack	98	9	.....	.....	.....	9	.....	.....	.....	.....
Total	1,085	10	7	28	2	47	$\frac{3}{8}$	$2\frac{1}{2}$	$\frac{1}{8}$	$3\frac{1}{2}$

[1] These ties were treated at the plant of the Texas Tie & Lumber Preserving Co. under the supervision of a representative of the Barschall Impregnating Co. The process, called also the Barschall process (Forest Service Bulletin 51), consisted of impregnations with a solution of copper sulphate, iron sulphate, alumina, and a small amount of kainit. The Barschall Impregnating Co. stated that certain of the ties showed decay before they were treated and that some of them were probably not properly treated because of a leak in the cylinder. Also, the records of treatment furnished by a representative of the company show that temperatures as high as from 224° to 270° were used during the treatments.

[2] Based on number of ties originally placed.

TABLE 6.—*Condition of ties treated with spirittine,*[1] *at Somerville, Tex., after seven and one-half years' service.*

Kind of wood.	Original number placed.	Ties remaining in track.					Serviceable ties remaining in track.			
		Decayed.	Partially decayed.	Good.	Split.	Total.	Partially decayed.	Good.	Split.	Total.
		No.	*No.*	*No.*	*No.*	*No.*	*Per ct.*[2]	*Per ct.*[2]	*Per ct.*[2]	*Per ct.*[2]
Pine, loblolly	100	2	.....	.....	.....	2	.....	.....	.....	.....
Pine, longleaf	100	.....	.....	17	3	20	.....	17	3	20
Total	200	2	.....	17	3	22	.....	$8\frac{1}{2}$	$1\frac{1}{2}$	10

[1] The ties were thoroughly seasoned and were soaked in the preservative 24 hours. The absorption averaged 3.3 pounds per cubic foot.

[2] Based on number of ties originally placed.

TABLE 7.—*Condition of untreated ties after seven and one-half years' service.*

Kind of wood.	Original number placed.	Ties remaining in track.					Serviceable ties remaining in track.			
		Decayed.	Partially decayed.	Good.	Split.	Total.	Partially decayed.	Good.	Split.	Total.
	No.	*No.*	*No.*	*No.*	*No.*	*No.*	*Per ct.*[1]	*Per ct.*[1]	*Per ct.*[1]	*Per ct.*[1]
Beech	87									
Hemlock	101									
Oak, black	25									
Oak, red	93	6				6				
Oak, Spanish	20									
Oak, turkey	20									
Oak, white	196	5	27	13	4	49	14	6½	2	22
Oak, willow	21									
Pine, loblolly	100									
Pine, longleaf	93	6				6				
Pine, shortleaf	100	1				1				
Tamarack	49									
Total	905	18	27	13	4	62	3	1½	½	5

[1] Based on number of ties originally placed.

TABLE 8.—*Condition of ties treated by the Wellhouse process,*[1] *at Chicago, Ill., after seven and one-half years' service.*

Kind of wood.	Absorption[2] dry salt.	Original number placed.	Ties remaining in track.					Serviceable ties remaining in track.			
			Decayed.	Partially decayed.	Good.	Split.	Total.	Partially decayed.	Good.	Split.	Total.
	Lb. per cu. ft.		*No.*	*No.*	*No.*	*No.*	*No.*	*Per ct.*[3]	*Per ct.*[3]	*Per ct.*[3]	*Per ct.*[3]
Beech	0.87	100		9	51	40	100	9	51	40	100
Hemlock	.54	100	9	12	66	9	96	12	66	9	87
Oak, black	.53	86	3	9	43	17	72	10	50	20	80
Oak, white	.35	100	1	7	60	28	96	7	60	28	95
Tamarack	.58	100	3	11	72	14	100	11	72	14	97
Total		486	16	48	292	108	464	10	60	22	92

[1] These ties treated by the Chicago Tie & Timber Preserving Co. The treatment consisted of three injections: (1) A 4 per cent solution of zinc chloride; (2) a 2 per cent solution of glue; (3) a 2 per cent solution of tannin.

[2] Based on weights of sample ties of each lot before and after treatment.

[3] Based on number of ties originally placed.

TABLE 9.—*Condition of ties treated by the Wellhouse process,*[1] *at Somerville, Tex., after seven and one-half years' service.*

Kind of wood.	Original number placed.	Ties remaining in track.					Serviceable ties remaining in track.			
		Decayed.	Partially decayed.	Good.	Split.	Total.	Partially decayed.	Good.	Split.	Total.
		No.	*No.*	*No.*	*No.*	*No.*	*Per ct.*[2]	*Per ct.*[2]	*Per ct.*[2]	*Per ct.*[2]
Oak, black	33	2	7	6	.....	15	21	18	.....	39
Oak, red	20	.....	.....	.....	.....	.....	.....	.....	.....	.....
Oak, Spanish	20	2	3	15	.....	20	15	75	.....	90
Oak, turkey	20	.....	.....	2	.....	2	.....	10	.....	10
Oak, white	100	.....	7	41	10	58	7	41	10	58
Oak, willow	20	1	.....	9	2	12	.....	45	10	55
Pine, loblolly	100	23	16	49	11	99	16	49	11	76
Pine, longleaf[3]	100	1	5	35	4	45	5	35	4	44
Pine, shortleaf	100	.....	2	19	.....	21	2	19	.....	21
Total	513	29	40	176	27	272	8	34	5	47

[1] These ties were treated at the plant of the Texas Tie & Lumber Preserving Co. The treatment consisted of two injections: (1) A 2 per cent solution of zinc chloride containing glue; (2) a solution of tannin. The average absorption for all species was 0.33 pound of dry zinc chloride per cubic foot, various species being mixed in the same charge.

[2] Based on number of ties originally placed.

[3] On account of a change made in the location of some of the longleaf-pine ties and of the loss of some of the marking nails there is some doubt as to the accuracy of the records.

TABLE 10.—*Condition of ties treated with zinc chloride and Beaumont oil,*[1] *at Somerville, Tex., after seven and one-half years' service.*

Kind of wood.	Original number placed.	Ties remaining in track.					Serviceable ties remaining in track.			
		Decayed.	Partially decayed.	Good.	Split.	Total.	Partially decayed.	Good.	Split.	Total.
		No.	*No.*	*No.*	*No.*	*No.*	*Per ct.*[2]	*Per ct.*[2]	*Per ct.*[2]	*Per ct.*[2]
Pine, loblolly	81	4	7	39	31	81	8	48	38	95
Pine, longleaf	100	2	8	68	22	100	8	68	22	98
Total	181	6	15	107	53	181	8	59	30	97

[1] The ties were treated with a 2 per cent solution of zinc chloride and seasoned before treatment with oil. They were soaked in the oil 24 hours and absorbed on an average a little over 3 pounds per tie.

[2] Based on number of ties originally placed.

TABLE 11.—*Condition of ties treated with zinc chloride and English creosote,[1] at Beaumont, Tex., after seven and one-half years' service.*

Kind of wood.	Original number placed.	Ties remaining in track.					Serviceable ties remaining in track.			
		Decayed.	Partially decayed.	Good.	Split.	Total.	Partially decayed.	Good.	Split.	Total.
	No.	*No.*	*No.*	*No.*	*No.*	*No.*	*Per ct.*[2]	*Per ct.*[2]	*Per ct.*[2]	*Per ct.*[2]
Beech	50	.....	.....	.....	.....	.....	.....	.....	.....	.....
Gum, sweet[3]	10	.....	.....	2	.....	2	.....	20	.....	20
Hemlock	49	.....	.....	7	.....	7	.....	14	.....	14
Oak, black	76	.....	.....	.....	.....	.....	.....	.....	.....	.....
Oak, turkey	10	.....	.....	.....	.....	.....	.....	.....	.....	.....
Oak, white	107	.....	.....	.....	.....	.....	.....	.....	.....	.....
Oak, willow	11	.....	.....	.....	.....	.....	.....	.....	.....	.....
Pine, loblolly	51	.....	7	25	17	49	14	50	33	97
Pine, longleaf[4]	50	1	.....	26	4	31	.....	54	8	62
Pine, shortleaf[4]	50	.....	.....	8	.....	8	.....	16	.....	16
Tamarack	51	.....	.....	5	.....	5	.....	10	.....	10
Total	515	1	7	73	21	102	1⅓	14	4	19

[1] These ties were treated by the International Creosoting & Construction Co. They were first impregnated with an average of 15 pounds of a 2 per cent zinc chloride solution and, after seasoning for several months, were given a heavy injection of creosote. From the report of the operations it seems very probable that they were injured by excessive steaming and many of them were said to be of poor quality before treatment. It is reported that all of the removals were due to breakage and rail cutting.

[2] Based on number of ties originally placed.

[3] Forest Service Bulletin 51 reports these ties as Spanish oak.

[4] Because of a change made in the location of some of these ties and of the loss of some of the marking nails there is some doubt as to the accuracy of the records.

RESULTS.

The results secured from the last inspection made by the Forest Service in September, 1909, are given in Tables 1 to 11. Figures 1 and 2, which show graphically the results of the test, are based on this and other inspections.[1] The following deductions may be drawn:

(1) Zinc chloride is an effective preservative for ties subjected to the severe conditions under which these were laid. This is indicated especially by the Burnett and Wellhouse treatments made at Chicago (Tables 3 and 8), as a result of which 87 and 92 per cent, respectively, of these ties were serviceable after seven and one half years.

(2) A fairly heavy impregnation of zinc chloride is advantageous. Treatments by the Burnett and Wellhouse processes, made at Somerville, with 2 per cent zinc chloride solutions and average absorptions of 0.35 and 0.33 pounds of dry salt per cubic foot of wood, resulted in only 45 and 47 per cent, respectively, of serviceable ties after seven and one-half years' service (Tables 4 and 9). Similar treatments made at Chicago with a 4 per cent solution and average absorptions of 0.42 and 0.57 pound of dry salt per cubic foot resulted in 87 and 92 per

[1] The results of inspections made in 1905, 1906, 1907, 1908, and 1910 were courteously supplied by the officials of the Atchison, Topeka & Santa Fe Railway Co.; the Forest Service made inspections in 1903, 1904, and 1909 only.

cent, respectively, of serviceable ties after the same length of service (Tables 3 and 8).

(3) A light injection of creosote apparently adds to the effectiveness of zinc chloride treatments. The Allardyce treatments made at Somerville (Table 1) show 81 per cent of serviceable ties, while treatments made at the same plant with zinc chloride alone (Table 4) show only 45 per cent of serviceable ties after $7\frac{1}{2}$ years. Beaumont

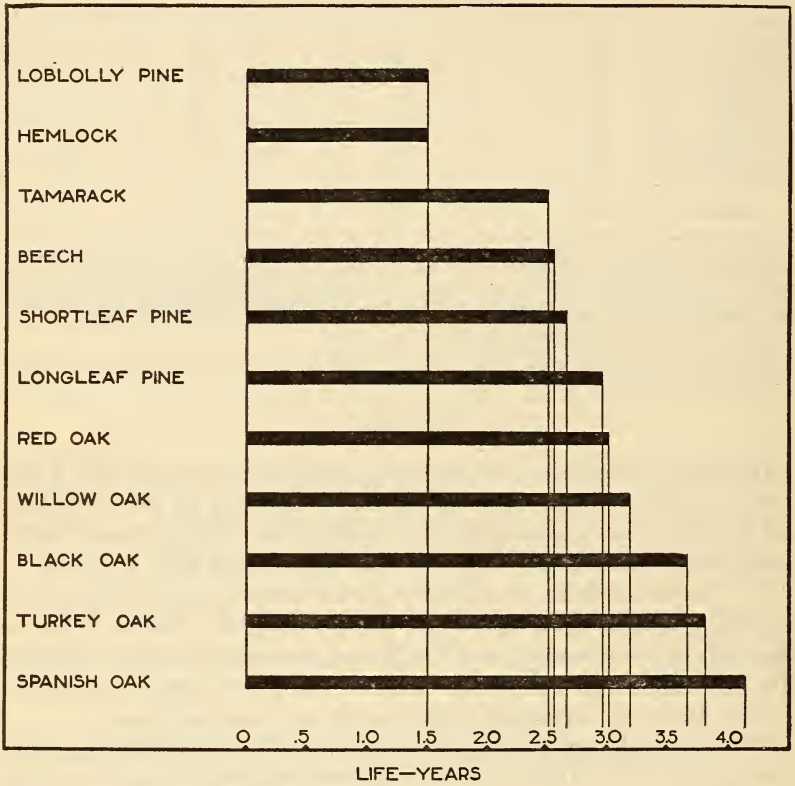

FIG. 1.—Average life of untreated ties laid in the experimental track of the Gulf, Colorado & Santa Fe Railway Co.

oil in combination with zinc chloride (Table 10) also produced an effective treatment.

(4) Treatment with preservatives will not yield good results unless the ties are sound in the first place and the treating is properly done. This is strikingly shown by the treatments with zinc chloride and English creosote (Table 11). These ties were probably injured by oversteaming during the treatment.

(5) The great variation in durability of the different species in nearly all of the treatments indicates that some of the species were

not properly treated, and emphasizes the necessity of separate treatments for each species.

(6) Species which, when untreated, decay most rapidly appear to give the greatest relative increase in service when treated. Loblolly

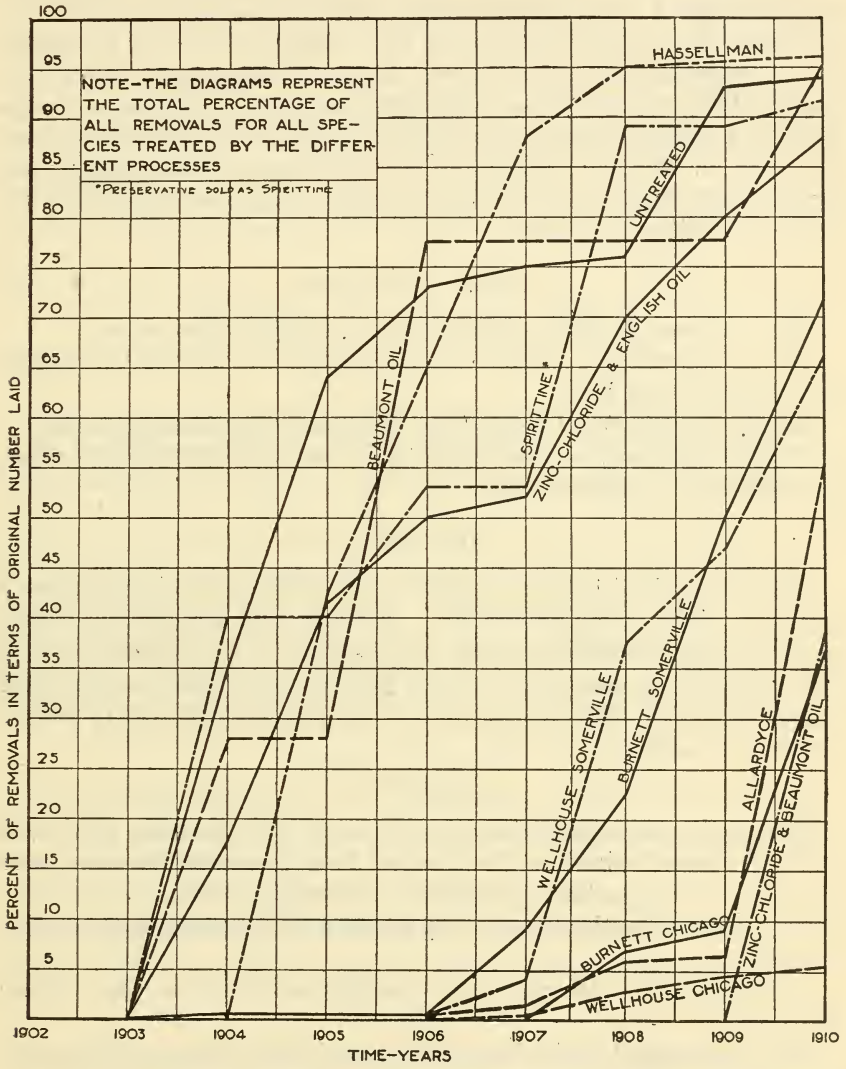

FIG. 2.—Tie removals from the experimental track of the Gulf, Colorado & Santa Fe Railway Co.

pine, hemlock, beech, and tamarack, which are the least resistant to decay when untreated, appear when treated to be about equally as durable as treated longleaf pine, Spanish oak, and white oak.

TEST TRACK LAID IN COOPERATION WITH THE NORTHERN PACIFIC RAILWAY CO., AT PLAINS, MONT.

DESCRIPTION OF TRACK.[1]

The 2,650 7 by 9 inches by 8 feet hewed ties which were placed in the main line of the Northern Pacific Railway Co., about 2 miles west of Plains, Mont., were laid during the summer of 1907 on a tangent with a uniform grade of 0.0167 per cent; the ballast is gravel and the general drainage conditions of the track are good. The line is single track and traffic is heavy. New 85-pound rail was laid when the ties were placed, with the exception of a small portion of the track which was changed at a later date. Several forms of tie-plates and both cut and screw spikes were used.

OBJECTS OF THE TEST.

This test was designed chiefly to secure information as to:

(1) The durability of green and air-seasoned untreated Douglas fir and western larch ties.

(2) The durability of burnettized Douglas fir and tamarack ties.

(3) The efficiency of the flanged, flat, and wooden tie-plates when used with cut or screw spikes.

TREATMENT.

The Burnettized ties were treated by the Great Northern Railway Co. in its plant at Somers, Mont. A 6 per cent solution was used, and the gauge readings showed an injection of 0.786 pound of dry zinc chloride per cubic foot. Both species were treated in the same charge and larch absorbed about 10 pounds of solution more per tie than the Douglas fir.

RESULTS.[2]

The track was inspected by the Forest Service in 1909, 1910, and 1911, the latest inspection being about four years after the ties were placed. The inspections yielded the following results:

(1) None of the ties showed any marked difference in their relative durability.

(2) Douglas fir ties were not checking as badly as the western larch ties.

(3) Ties treated with zinc chloride were more rail-worn than untreated ties of the same species.

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[1] For a more complete description see Forest Service Circular 146, "Experiments with Railway Crossties," by H. B. Eastman.

[2] From the reports of H. B. Oakleaf, Forest Assistant, and P. R. Hicks, Engineer in Forest Products, who made the inspections for the Forest Service in conjunction with officials of the Northern Pacific Railway Co.

(4) Untreated larch ties were more rail-worn than untreated Douglas fir ties, but were not as badly worn as the treated ties of either species.

(5) The flat metal plates were causing the ties less damage than any of the other plates used.

(6) Flanged tie-plates caused more checking and brooming than flat ones.

(7) The wooden plates did not prove serviceable, as they worked out from under the rail and split badly; moreover, they did not prevent wear of the ties.[1] They were removed during 1910 and replaced with metal plates.

(8) Because of lack of support under the head, the screw spikes tended to become bent by the lateral thrust of the rail.[1]

TEST TRACK LAID IN COOPERATION WITH THE NORTHERN PACIFIC RAILWAY CO. AT MAYWOOD, WASH.

DESCRIPTION OF TRACK.[2]

The 2,280 7 by 9 inches by 8 feet sawed ties which were placed in the main line of the Northern Pacific Railway Co. near Maywood (about 6 miles west of Hot Springs), Wash., were laid in the fall and winter of 1906–7. Two curves, one of 2° and the other of 5°, are included in this track. The grade varies from 0.46 to 0.96 per cent. The roadbed for the most part is an earth embankment well drained; gravel ballast is used exclusively. The track is laid with 72-pound rail; the traffic is exclusively heavy, and loaded trains pass in both directions. Screw spikes are used on a part of the track, both with and without tie-plates, and in various combinations with cut spikes.[3]

OBJECTS OF THE TEST.

The test was designed to yield information on the following points:

(1) The durability of green and air-seasoned untreated Douglas fir and western hemlock ties.

(2) The durability of creosoted Douglas fir ties.

(3) The efficiency of flat tie-plates in preventing wear and the relative efficiency of screw and cut spikes as rail fastenings.

TREATMENT.

Four hundred and fifty air-seasoned Douglas fir ties were treated by the full-cell creosote process in the plant of the Pacific Creosoting

[1] For discussion and illustration of this, see Forest Service Bulletin 118, "Prolonging the Life of Cross-Ties."

[2] For a more complete description, see Forest Service Circular 146.

[3] At the time this track was laid no spike-boring machine was available and the holes for the screw spikes were bored by hand. In some cases the holes were not bored deep enough and when the screw spikes were inserted they hit the bottom of the holes and on subsequent tightening stripped the threads in the wood. It is felt that a fair test is not being given to the screw spikes in this track.

Co. at Eagle Harbor, Wash. The ties were weighed before and after treatment, and again 90 days later. The increase in weight during treatment was 8.6 pounds per cubic foot. After 90 days air seasoning an average of 2.4 pounds of this increase had been lost, leaving the net increase 6.2 pounds per cubic foot.

RESULTS.[1]

The latest inspection of these ties was made by the Forest Service in June, 1911, approximately four and one-half years after placement. Following is a summary of the observations made:

(1) The green, untreated hemlock ties were beginning to deteriorate quite rapidly. Many of them had wood-destroying fungi growing upon them.

(2) The Douglas fir ties seemed to be better than the hemlock as far as checking, rail wear, brooming, and decay were concerned.

(3) The creosoted Douglas fir ties were decidedly more rail cut than the untreated ties.

TEST TRACK LAID IN COOPERATION WITH THE CHICAGO & NORTH WESTERN RAILWAY CO.

DESCRIPTION OF TRACK.

The 3,040 6 by 8 inches by 8 feet hewed ties placed in the main line of the Chicago & North Western Railway Co. near Janesville, Wis., were laid in December, 1907, on a level tangent. A change in the lines of the company subsequent to laying the ties has caused the traffic over the track to be very light, consisting only of passenger trains in one direction. The track is laid with 90-pound rail in well-drained gravel ballast.

OBJECTS OF THE TEST.

The test was designed to secure information as to:

(1) The natural durability of eastern hemlock and tamarack ties.

(2) The comparative efficiency of the Burnett, Wellhouse, and open-tank creosote processes.

(3) The comparative efficiency of flat and flanged metal ties-plates and creosoted wooden plates and of cut and screw spikes used with treated ties.

TREATMENT.[2]

The ties were treated with zinc chloride at the plant of the Chicago & North Western Railway Co. at Escanaba, Mich., by both the Bur-

[1] From the reports of H. B. Oakleaf, Forest Assistant, and P. R. Hicks, Engineer in Forest Products, who made the inspections for the Forest Service in conjunction with officials of the Northern Pacific Railway Co.

[2] For a more complete description of the treatments see Forest Service Circular 132, "The Seasoning and Preservative Treatment of Hemlock and Tamarack Cross-Ties," by W. F. Sherfesee.

nett and Wellhouse processes. A 4 per cent solution was used, and the injection averaged about 12 pounds of solution per cubic foot. Some of the ties were given an open-tank treatment with coal-tar creosote and absorbed about 15 pounds per tie. The record of absorption of each tie is on file with the Forest Service, and as the ties begin to fail the relation of the absorption to the failure will be studied.

RESULTS.

The latest inspection of this track was made by the Forest Service in May, 1911. Table 12 shows the condition of the untreated ties at that time, after about three and one-half years' service. Approximately 15 per cent of the untreated hemlock and 13 per cent of the untreated tamarack ties were so badly decayed that they were unserviceable; in addition, about 8 per cent of the hemlock and 30 per cent of the tamarack were less seriously affected with decay.

The following additional observations were made:

(1) Only two of the treated ties showed any evidence of decay.

(2) About 44 per cent of the hemlock and 60 per cent of the tamarack ties which were untreated and unprotected by plates were rail cut to a depth varying from one-fourth to one-half inch and practically all showed rail wear to some extent.

(3) There was no apparent difference in the condition of the ties equipped with flat plates and cut spikes and those having flat plates and screw spikes. In both cases when the surface of the tie was uneven there was some plate wear, the maximum being about one-fourth inch.

(4) Many of the flanged plates were still only partially embedded in the ties and gravel was found under a good many of them. As a result, some of the plates were bent and twisted.

(5) The damage to the ties with wooden plates appeared to be less than to those otherwise protected, but some of the plates were missing and many were split and damaged to some extent. It appears, therefore, from this and other experiments, that the successful use of wooden plates depends largely on the frequency of their inspection and replacement.

(6) Lack of support under the outer portion of the head of the screw spikes had, in some cases, resulted in the spikes bending outward from the rail. This effect is greater with the wooden plates than with any of the others.[1]

[1] This is discussed and illustrated in Forest Service Bulletin 118, "Prolonging the Life of Cross-Ties."

TABLE 12.—*Condition of untreated ties in the test track of the Chicago & North Western Railway Co. after three and one-half years' service.*

Lot No.	Species.	Time seasoned.	Season cut.	Condition while seasoning.	Number of ties.	Condition as found on inspection.			
						Good.	Partially decayed.	Decayed.	Worn.
		Months.				*Per ct.*[1]	*Per ct.*[1]	*Per ct.*[1]	*Per ct.*[1]
57	Hemlock...	29	Summer..	Peeled and soaked for few days prior to seasoning.	20	50	10	20	20
58	.....do.....	28	.....do.....	Peeled.....	20	45	10	.....	45
59	.....do.....	26	Fall.....	.....do.....	20	45	.....	15	40
60	.....do.....	23	Winter....	.....do.....	20	65	5	15	20
61	.....do.....	26	Fall.....	.....do.....	20	35	.....	25	40
62	.....do.....	35	Winter....	.....do.....	20	20	10	40	40
63	.....do.....	11	.....do.....	Unpeeled on two sides.	50	26	14	4	66
	Total.	.....	.....	.....	170	37.6	8.2	14.7	43.5
64	Tamarack..	23	Winter....	Peeled.....	25	16	24	20	56
65	.....do.....	23	.....do.....	Unpeeled on two sides.	25	32	16	4	60
66	.....do.....	35	.....do.....	Peeled.....	20	35	15	10	70
67	.....do.....	11	.....do.....	Unpeeled on two sides.	62	14.5	37	14.5	58
	Total.	.....	.....	.....	132	19.7	29.5	12.9	59.8

[1] Based on number of ties originally placed.

TEST TRACK LAID IN COOPERATION WITH THE INDIANAPOLIS, COLUMBUS & SOUTHERN TRACTION CO.

DESCRIPTION OF TRACK.

The 945 6 by 8 inch by 8 feet hewed ties laid in cooperation with the Indianapolis, Columbus & Southern Traction Co. were placed in September, 1909, in the main line of this company near Taylorsville and Edinburg, Ind. With the exception of a few ties which are placed in a sharp curve, all are in an approximately level tangent. The roadbed is fairly well drained; the ballast is gravel containing some sandy soil. The track is laid with 65-pound rail without tie-plates and with ordinary cut spikes. Traffic is light, and is confined to interurban electric cars.

OBJECTS OF THE TEST.

The test was designed to secure information on the comparative efficiency of red and black oak ties treated with coal-tar creosote (full-cell process), zinc creosote, and "asphaltic crude oil," [1] using low pressures.

TREATMENT.

The ties used in this track were treated in the low-pressure wood-preserving plant of the Indianapolis, Columbus & Southern Traction Co. All were thoroughly air seasoned. Those treated with creosote

[1] This preservative was contributed for the experiment by the Indian Refining Co., of Cincinnati, Ohio.

were boiled in the oil at a temperature not exceeding 225° F. from one to four hours, after which a pressure not exceeding 45 pounds per square inch was applied until the desired absorption was obtained. Those treated with creosote and zinc chloride were first heated in creosote for one hour at a temperature varying between 200° and 212° F., after which they were impregnated with a 4½ per cent solution of zinc chloride under a pressure of not more than 45 pounds per square inch. In the treatments with "ashphaltic crude oil" the injection was very light. On account of the viscous nature of the oil it was not possible to apply pressure exceeding 20 pounds per square inch with the apparatus used. Table 13 shows the character of treatment given the ties placed in this test.

TABLE 13.—*Condition of treated red oak ties in the test track of the Indianapolis, Columbus & Southern Traction Co. after two years' service.*

Character of treatment.		Total number of ties.	Condition as found on inspection.			
Preservative.	Absorption (per cubic foot).		Good.	Partially decayed.	Split.	Worn.
			Per cent.[1]	*Per cent.*[1]	*Per cent.*[1]	*Per cent.*[1]
Coal-tar creosote....	About 14 pounds maximum absorption.	99	83.9	2	14.1	.....
Do.....	12 pounds.....	53	86.9	.....	11.3	1.8
Do.....	7 to 8 pounds.....	429	94.4	.....	5.6	.....
Creosote and $ZnCl_2$.	0.46 to 0.55 pound $ZnCl_2$, 3 to 4 pounds creosote.	198	84.4	12.1	5	.5
Asphaltic crude oil.	Indeterminate, but very slight.	167	86.2	.....	13.8	.....

[1] Based on number of ties originally placed.

RESULTS.

The latest inspection of ties was made by the Forest Service in September, 1911, two years after placement. Table 13 shows their condition at that time. Following is a summary of the observations made:

(1) No badly decayed ties were found, although approximately 2 per cent of those treated with about 14 pounds of creosote per cubic foot and approximately 12 per cent of those treated with creosote and zinc chloride were slightly affected with decay. This is probably due to the fact that some of the ties were affected at the time of treatment.

(2) A number of the ties of each treatment were more or less split on the ends. In practically all such cases, however, the exposed portions of the ties appeared thoroughly sound and well treated, and it is probable that the greater part of the splitting existed at the time of treatment.

(3) Only two of the ties showed any rail wear, and this was so slight as to be negligible.

TEST TRACK LAID IN COOPERATION WITH THE TENNESSEE COAL, IRON & RAILROAD CO.

DESCRIPTION OF TRACK.

The 920 7 by 9 inches by 8 feet sawed ties placed in cooperation with the Tennessee Coal, Iron & Railroad Co. were laid in the spring of 1910 in a portion of the track of the Birmingham Southern Railroad Co. just south of the steel plant of the company at Ensley, Ala. Most of the ties are in a tangent. Slag is used for ballast. The roadbed is level and drainage is poor. Seventy-pound rail is used, with ordinary cut spikes. At first pronged tie-plates were used only on curves, but about one year later these were placed on all ties. The traffic consists of heavily loaded ore cars.

OBJECTS OF THE TEST.

The test was designed to secure information as to:

(1) The natural durability of longleaf pine and white-oak ties.

(2) The comparative efficiency of "cresol-calcium"[1] and coal-tar creosote in protecting shortleaf pine, loblolly pine, and red-oak ties from decay when treated by the low-pressure process.

TREATMENT.

The treatments were made at the plants of the Tennessee Coal, Iron & Railroad Co. near Birmingham, Ala. The shortleaf and loblolly pine ties which were treated with creosote received an injection of 7 pounds of oil per cubic foot of wood, injected under a pressure of not more than 40 pounds per square inch. In the cases of the red-oak ties treated with creosote and the pine ties treated with cresol-calcium, a vacuum of about 10 inches was first drawn and the preservative was then admitted to the cylinder; a pressure of from 10 to 15 pounds per square inch was applied until the desired absorption was secured. Table 14 shows the number of ties of each class placed in this track and the treatment given each lot.

RESULTS.

An inspection of this track was made about six months after it was placed. All of the ties were sound and free from wear.

[1] This preservative was contributed by Messrs. Blagden, Waugh & Co., London, England.

TABLE 14.—*Treatment given ties used in the Tennessee Coal, Iron & Railroad Co. test track.*

Species.	Preservative.		Absorption.	Tie numbers.
	Kind.	Strength of solution.		
		Per cent.	*Lbs. per cu. ft.*	
Shortleaf and loblolly pine	Cresol-calcium	9.7	[1] 1.15	5–108
Do	do	7.5	[1] 0.85	109–213
Do	do	5.0	[1] 0.51	214–315
Do	do	2.5	[1] 0.27	316–417
Red oak	Creosote		5.54	622–722
Shortleaf and loblolly pine	do		7.0	418–621
Longleaf pine	Untreated			824–924
White oak	do			723–823

[1] Dry salt.

TEST TRACK LAID BY THE WENATCHEE VALLEY & NORTHERN RAILWAY CO.

The Wenatchee Valley & Northern Railway Co. placed 100 test ties in the main line of its track near Delmont, Wash., in July, 1910. The ties were hewed on two faces, the bark being left on the sides, and were air seasoned for approximately one year before they were placed in the track. Sixty-pound rail and cut spikes were used. The roadbed is a slight fill with good drainage ditches on both sides; the ballast is a light sandy loam; the grade is 2 per cent. Traffic over the line is light.

The information to be secured from this track is data on the comparative durability of untreated hewed ties of Douglas fir, western yellow pine, lodgepole pine, and grand fir. The ties have not been placed sufficiently long to furnish any results.

TEST TRACK LAID IN COOPERATION WITH THE CHICAGO, MILWAUKEE & ST. PAUL RAILWAY CO.

DESCRIPTION OF TRACK.[1]

The test ties placed in the main line of the Chicago, Milwaukee & St. Paul Railway Co. near Hartford, Wis., were laid in August, 1911. Seventeen hundred and eleven hewed and sawed 6 by 8 inches by 8 feet ties constitute the test. The ties are placed in a level tangent on a well-drained roadbed. Gravel is used for ballast; traffic is fairly heavy, and trains pass over the line in both directions; new 90-pound rail was laid. In general, one-half of these ties are plated with flat steel plates having boss under the spike heads, and screw spikes are used; the rest are unplated and the rail is fastened with cut spikes. Malleable iron ribbed plates (with cut spikes) are used on a few of the ties.

[1] A full description of this track and a record of the treatment given the ties is found in Forest Service Bulletin 126, "Experiments in the Preservative Treatment of Red Oak and Hard Maple Cross-Ties," by F. M. Bond.

OBJECTS OF THE TEST.

The test should yield information as to—

(1) The natural durability of red oak and hard maple ties.

(2) The efficiency of the Burnett, Card, zinc-creosote, full-cell creosote, Rueping, and crude-oil treatments in protecting red oak and maple, and the kyanizing process in protecting spruce ties from decay.

(3) The efficiency of flat-bottom plates when laid with screw and cut spikes in protecting ties from mechanical wear.

TREATMENT.

All of the treated ties were impregnated at the Forest Products Laboratory with the exception of 262 burnettized red oak, 21 burnettized chestnut, and 25 kyanized spruce ties,[1] which were treated at commercial plants and added to the experiment that was originally planned. Complete records of the ties treated at the Forest Products Laboratory are available,[2] and these include treatment records for each charge, the absorption of each tie, its moisture content at the time of treatment, volume, oven-dry weight of the wood, and other characteristics which might have affected the behavior of the tie under treatment or its durability. A list of the ties placed, with the character of treatments applied to the various lots, is given in Table 15.

The track has not been in existence sufficiently long to furnish any results.

TABLE 15.—*Manner in which the ties in the Chicago, Milwaukee & St. Paul test track were treated and laid.*

Kind of wood.	Process.	Preservative.		Ties laid.	Ties plated.	Numbering nails.
		Kind.	Amount injected.			
			Lbs. per cu. ft.	*Number.*	*Number.*	
Red oak	Full-cell	Creosote	10.9	102	52	[3] 101–200
Do	Rueping	do	5.3	100	50	1–100
Do	Burnett	Zinc chloride	[4] ½	100	50	201–300
Do	do.[5]	do	[4] ½	262	262	[6] 1301–1400 2001–2154
Do	Card	Zinc chloride and creosote	[7] 15.3	100	50	1201–1300
Do	Two-movement	do	[8] 15.3	100	50	801–900
Do	Full-cell	Semirefined oil, paraffin base	7.3	100	50	601–700
Do	Untreated			100	50	701–800
Hard maple	Full-cell	Creosote	12.0	100	50	501–600
Do	Rueping	do	4.9	100	50	401–500
Do	Burnett	Zinc chloride	[4] ½	100	50	301–400
Do	Card	Zinc chloride and creosote	[7] 16.0	100	50	1101–1200
Do	Two-movement	do	[8] 15.5	100	50	1001–1100
Do	Full-cell	Semirefined oil, paraffin base	12.6	100	49	1401–1500
Do	Untreated			100	50	1501–1600
Spruce	Kyanized[5]	Mercuric chloride		25	13	901–925
Chestnut	Burnett[5]	Zinc chloride	[4] ½	21	21	[9] 926–947

[1] The kyanized spruce ties were contributed by the Berlin Mills Co., of Manchester, N. H.
[2] Forest Service Bulletin 126.
[3] Two ties with subnumbers.
[4] Dry salt.
[5] Treated at commercial plant.
[6] Eight ties with subnumbers.
[7] Emulsion.
[8] Mixture.
[9] One number missing.

SUMMARY.

Since 1902 the Forest Service has constructed eight test tracks in cooperation with seven different railroad organizations. Because a long time must elapse before data can be obtained on durability, few of these tracks have thus far yielded conclusive results. The information already received indicates that test tracks, if properly constructed and inspected, prove a valuable index in showing economies in track maintenance.

So far as can be told by present results, all treatments, with one exception, have increased the durability of the ties over that of similar untreated material. Just how much the natural life of the ties can be prolonged is not yet determined, but that it may in many cases be doubled or even trebled seems certain. For example, untreated loblolly pine and hemlock ties laid in Texas lasted only 1.5 years, while of those burnettized over 70 per cent were still serviceable after seven years.

Ties with low decay resistance, such as loblolly pine, hemlock, tamarack, and beech, if laid untreated, should not be tie-plated, as they will decay before they will wear out.

The increased resistance to decay secured from preservative treatment makes it highly desirable to protect treated ties from deterioration by mechanical cause. This is particularly true of ties with low-crushing strength.

Experience thus far is not conclusive as to the best form of plates to use. Wooden plates, when simply laid under the rail, have not proved satisfactory, as they either become loose, split, or, in some cases, become embedded in the tie. Flanged metal plates have a decided tendency to split the tie, thus forming cracks which enable moisture to reach the interior and hasten decay. Metal plates with flat or slightly corrugated bottom have thus far given the best results.

Service tests on screw and cut spikes have, to the present time, yielded no definite conclusions. It has been shown, however, that when screw spikes are used it is desirable to have some form of boss on the plates to reenforce the heads of spikes against lateral thrust.

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